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Brooklyn. Board of Water Commissioners

A

REPORT

ON THE

EXTENT AND CHARACTER OF THE DISTRICT SUPPLYING WATER

TO THE

CITY OF BROOKLYN.

BY

THEODORE WESTON, C. E.

WITH A

COMMUNICATION IN RELATION TO THE SAME,

FROM

JAMES P. KIRKWOOD, ESQ.
ENGINEER OF THE WORKS.

AND AN

ANALYSIS OF THE WATER OF THE JAMAICA RESERVOIR,

BY PROF. A. K. EATON, CHEMIST.

BROOKLYN, N. Y.
1861.

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1862. June 4
Gift of
William Ezra Worthen
of New York City
(Class of 1838)

D. VAN NOSTRAND,
PUBLISHER.

REPORT.

Brooklyn Board of Water Commissioners,
MAY 10th, 1860.

A COMMUNICATION was received from the Chief Engineer, with a map of the drainage area of the streams from which the supply of the city is now arranged to be procured, together with two sheets of profiles, showing certain characteristics of the great water reservoir under the Hempstead Plains, and a report from Mr. T. Weston, explanatory of this drainage; also a report from Professor A. K. Eaton, showing a gradual improvement of the character of the water of Jamaica Pond during the first season, &c.

Referred to Messrs. Brevoort and Brush, with the power to print.

ENGINEER'S OFFICE, *May 9th*, 1860.

WILLIAM WALL, ESQ.,
Vice-President, &c.

SIR:—I submit herewith a map of the drainage area or water-shed of the streams from which the supply of the city of Brooklyn is now arranged to be procured, together with profiles, showing certain characteristics of the great water reservoir under the Hempstead Plains, and an interesting report from Mr. Weston, explanatory of this drainage.

In a note to my report on the gaugings of the different supplying streams (January, 1858), I estimated, from the map of Long Island, the drainage area referred to as comprising about thirty-four square miles.

The old map of Long Island, from which I made this measurement, was too general and indefinite in its character to furnish correct results of this kind; I therefore directed Mr. Weston, last Fall, to take advantage of the leisure which the stoppage of the mason-work on the conduit presented, to obtain a correct outline of the drainage-basin. To this he applied the conduit parties in December last, and the service has been performed by all concerned very satisfactorily.

Instead of 34 square miles of available watershed, as I had supposed from the old map, the correct survey shows an aggregate of 60$\frac{1}{4}$ square miles connected with the streams which are now prepared for use, and 13 square miles of unapplied drainage area, belonging to Springfield Pond, and various small streams not available for pondage.

Of the average annual rain-fall falling upon any river-basin, a certain fraction finds its way into the channel of the stream, either directly upon the surface, or after percolation through the earth and strata underneath. Another fraction is consumed by evaporation and vegetation, and another fraction finds its way towards the sea by underground crevices and channels, and never escapes again to the surface.

This last fraction must be more than usually large on the Hempstead Plains basin, where the natural formation presents no rocks or clay to intercept the last-described portion of the rain-fall and force it to the surface, but, on the contrary, presents no obstacle to its descent seaward on the spaces of ground intervening between the various valleys, except the friction of the particles of sand, found in this case to be equal to a rate of descent of 12 feet to the mile.

It has long appeared to me that much of this last portion of the reservoir water might be intercepted by underground drainage; but it might require these drains to be placed so low as to involve pumping to deliver the water into the conduit.

The water thus obtained is pure and limpid, and entirely free from the discoloration which attends, more or less, the water of the open streams. The subject, at some future time, will merit a closer study.

The water of some of the streams is sometimes found to be slightly brown in color. The Jamaica Pond water, when first used, was at times considerably tinted in this way; it is but little affected in this way now, though the evil can never, in my opinion, be entirely obviated until certain deposits of muck above the pond are either partially or wholly removed. The muck thrown out from Jamaica Pond was, during the first season, covered in spots with a white efflorescence of a bitter taste; and a similar salt was found deposited on the gravel at the water's edge of the upper end of the pond.

The pools of standing water outside of the pond, lying in contact with the muck spoil banks, had the same bitter taste.

I sent, at that time, specimens of the water of the pond, drawn from different points, and of these pools, to Prof. Eaton, chemist, for examination, and submit herewith his report thereon. His report is very satisfactory, as showing a gradual improvement in the character of the water of Jamaica Pond during the first season, and a probability that the same depth of discoloration will not occur again.

To rid all the streams of the impurities referred to, and the tendency to discoloration growing out of the large deposit of muck in their channel-ways, will be a work of considerable time.

Within the limits of the different supply reservoirs, the muck has been entirely removed; but, above the reservoirs, nothing has been done as yet to separate the channels of the streams from the vegetable accumulation through which they flow.

At Jamaica Pond the discoloration can be readily traced to the cause suggested. When the pond is drawn down 12 or 18 inches, so that its surface water does not correspond with the surface of the bog or swamps above, the discoloration all but ceases; for the rapid flow of the water through a channel situated in the muck deposit seems to affect it but little, compared with its slow progress there when the surface of the water lies steeping over the surface of the bog.

At Jamaica Pond, the removal of the muck on Rider's Creek would tend much to the improvement of the water there; and the excavation of a wide channel-way in the main creek would, it is thought, be of service in the same way. Instead of removing the muck where the deposit is large, it may answer the same purpose to cover its surface with two or three feet of sand or gravel, enlarging, at the same time, and straightening the channel of the stream.

This will prevent the water spreading over the bottom as now, and confine it to the creek channel.

Jamaica Pond water appears to be more subject to discoloration than the water of the other ponds, arising, probably, from the fact that the accumulation of vegetable matter in the valley of this stream is much greater than in the valleys of the other streams; from which it may be inferred that this stream was ponded and used long before the other streams to the east of it.

The other ponds show a better color of water than Jamaica, and when the new conduit is finished, and their waters can be brought down, they will probably modify and improve much the tone of the present water.

Some legislation seems necessary to give the city the right hereafter to take such action in the valleys of the streams as will secure at all times pure water, whether by mucking out those valleys gradually, or following the other course suggested above.

JAMES P. KIRKWOOD.

James P. Kirkwood, Esq.,
Engineer Brooklyn Water Works.

Dear Sir:—At your request I have made a full analysis of the water of Jamaica Pond, the source of the present supply of water to the city of Brooklyn, and also partial analyses of the water of Beaver Creek, which flows into this pond, and of that of some pools outside the pond, at points designated as stations 19 and 24 (see sketch).

The analysis of the water from the centre of the pond gives the following results in grains per gallon:—

		COMBINED AS FOLLOWS:	
Lime,	.697	Carbonate of Lime,	.998
Magnesia,	.211	Sulphate of Lime,	.332
Sodium,	.073	Chloride of Sodium,	.186
Phosphates (iron and alumina),	.369	Carbonate of Magnesia,	.577
Sulphuric Acid,	.195	Phosphates: iron and alumina,	.369
Chlorine,	.113	Silica,	.703
Carbonic Acid, in combination,	.804	Organic matter and loss,	1.234
Silica,	.703		
Organic Matter,	1.234		
	4.399		4.399

Comparing these results with others obtained from examination of the water as taken from the pipes in Brooklyn May 18th, 1859, and again from the pond Sept. 1st, 1859, there appears to have been a decided improvement taking place in the quality of the water up to the period when the sample was taken, of which the analysis is given above. This was Dec. 23d, 1859. This is readily seen by placing the results together, as follows:—

	Water of May 18th.	Water of Sept. 1st.	Water of Dec. 23d.
Organic matter, grains per gall.,	3.285	1.852	1.234
Inorganic matter, " "	5.475	4.478	3.165
Solid residue, " "	8.760	6.330	4.399

The impurities in the water examined in May were owing, no doubt, in part to the accumulation of foreign matters in the pipes previous to the distribution of the water, as the pipes were then just opened. The proportion of iron obtained in December was much less than in either of the preceding examinations, and this is a direct effect of the diminution of saline matters in the pond water, the character and source of which will be noted below.

The next examination is of the water of Beaver Creek, a swift-running stream, which is the chief source of supply of the pond. This proves to be a purer water than that of the other streams, and contains much less oxide of iron and less of the sulphates than the pond water. It gives, by evaporation,—

Organic matter, in grains per gallon,		......	1.120
Inorganic matter,	" "	......	2.991
Solid residue,	" "	......	4.111

In the inorganic matter I detected chloride of calcium, the presence of which accounts for a remarkable cloudiness that is produced as the waters of the brook meet those of the pond. For the latter, containing soluble sulphate of iron and alumina, a double decomposition takes place, and a cloudy precipitate of sulphate of lime is produced, which is distinctly perceptible in the large bulk of water, though not noticeable when the experiment of mixing is tried in small portions.

Along the margin of the pond on the east side, and separated from it by a sand-beach, are pools of water, resulting from the drainage of the muck spoil banks; these are the great collections of peat and muck that were extracted from the bed of the pond and spread over the fields in its vicinity. With the vegetable matters there occurred considerable quantities of bisulphuret of iron, and more or less clayey or aluminous earth. As the heaps lay exposed to the weather, the iron pyrites decomposed; the sulphur, combining with atmospheric oxygen, formed sulphuric acid, and the iron became an oxide, with which a portion of the sulphuric acid uniting formed a sulphate of oxide of iron; while another portion, uniting with the alumina of the clay, formed, with the former, a double sulphate of alumina and iron. The quantity of this salt was sufficient, when scattered over the surface of the heaps, to be everywhere perceptible during the warm weather in the Summer, in the form of an efflorescence, and to communicate a decided sulphurous odor to the atmosphere around. It is readily dissolved by water, and is washed down by the rains to the lowest levels. The ditches along the margin of the pond are for the purpose of catching this drainage, and preventing its entrance into the pond. This is, in great part, effected by the sand beach; but, as the water in the pools rises and falls with that of the pond, the communication between them is not entirely cut off, and it is possible that some of the impurities of the pools may filter through. The examination of this water affords an indication of the kinds of impurities that may thus be introduced; but it is to be remarked that the quantity is likely to diminish, as the superficial layers of muck become exhausted of their saline materials. Indeed, by comparing the results of examinations made at the interval of about four months, I find the proportion of saline matter has already sensibly diminished.

The water of the pool at station 19 is remarkable for its large proportion of impurities. It is of a deep reddish-brown color, and strong styptic taste,—an ounce of it gives distinct crystals of the double salt of sulphate of oxide of iron and alumina. A gallon gives, by evaporation, a solid residue of 183.659 grains, consisting of inorganic matter, 123.909 grains; and organic matter, with water of crystallization, 59.750 grains.

The water from station 24 is highly colored by organic matter, and, in September last, it manifested even to the taste the presence of a considerable amount of the double salt already named. In December, however, this had nearly disappeared. A gallon of the water yielded, by evaporation, a solid residue of 12.840 grains, consisting of inorganic matter, 7.074 grains, and organic matter, 5.766 grains.

These investigations suggest the following conclusions:

1st. The most noxious impurities that find their way into the water of the pond are derived from sources that are rapidly becoming exhausted in great part. And, moreover, they undergo such changes in the pond that they are converted into harmless, inert, and insoluble compounds, which are likely to remain, to considerable extent, as precipitates in the pond itself, or in the reservoir at Ridgewood Hill, where sediments can again subside before the final distribution of the water.

2d. While the supply of water is primarily derived from the purest springs of the diluvial sands and gravel, the contaminations are almost wholly furnished by the vegetable deposits, through which the streams flow before they are discharged into Jamaica Pond. Hence, the clearing out of these channels is an object of primary importance, should any objections be found to the quality of the water now furnished to the city. Some of the smaller streams are decidedly sluggish, and their course is through low swamps, of similar character to the bed of Jamaica Pond before this was cleaned out.

The experience of another Summer will better determine the expediency of prosecuting this work, which, the further up the sources it is extended, must unquestionably increase both the quantity and the purity of the water supplied to Brooklyn.

Respectfully, yours,

A. K. EATON.

72 Beaver St., New York,
Jan. 11*th,* 1860.

PREFACE.

It will be noticed that the following report was rendered in March, 1860, but, at the Commissioners' suggestion, a further inquiry into the whole amount of fresh water discharged from the drainage-basin into Jamaica and Hempstead bays was resolved upon; and no favorable opportunity offering, while active construction of the Conduit Extension works was progressing, to prosecute the necessary experiments, a completion of the report with these additions was consequently postponed until the Summer's work was finished. It was thought best to incorporate the result of the investigations in relation to the bay into the body of the report, rather than append it in a separate form.

Three maps were first made, two of them exhibiting profiles of the country, on rather a larger scale, and somewhat more in detail than is now presented; it was considered, however, desirable to condense the whole into a single representation, as offering more ready facilities for comparison.

To those who are not familiar with the character of country on the south side of Long Island, or with the plan of water supply to the Brooklyn Works, it may not be improper to briefly explain its main features.

From Brooklyn, where the contour of the ground is somewhat broken, the irregular eminences are collected together in the neighborhood of the village of East New York, and then stretch, as a single ridge, very directly eastward, dividing the Island into two portions,—that on the north being of an aluminous, heavy soil, of which the ridge itself is mostly composed; while that on the south side is entirely sand, of a very equal quality, being disintegrated granite, probably deposited by the ocean currents against the base of the ridge, which seems to have been the terminal morain of a glacier. This sand-deposit, by constant accumulation, has grown out into the ocean, and thus the plains have been formed which constitute the gathering grounds for our works.

The drainage of the country between the city of Brooklyn and Jamaica has not in any way been used; but, from the neighborhood of that village to, and rather beyond Hempstead, the water yield of the country has been appropriated. The drainage of this district has collected itself into seven considerable streams, which we have designated as Jamaica, Springfield, Brookfield, Clear Stream, Valley Stream, Rockville and Hempstead Creeks. The flow of one of these, Springfield, has not, as yet, been included in the supply. Each of these streams, having a fall of about eight feet per mile, and being from three to eight miles long, has been ponded at various places since the settlement of the Island, and the water used for mill purposes. A pond on each stream was purchased by the city of Brooklyn, and the right of taking the whole flow granted that corporation. These ponds were found to be filled, more or less, with decayed vegetable matter, or muck, depending in amount upon the length of time they had been dammed up. Sections of them are shown on the map, with the depth of muck found in each. New dams were carefully constructed, with weirs and gate-houses of masonry. From each a barrel-conduit of brick, varying from 2 feet to 3 feet 6 inches in diameter, takes the yield of the pond and empties it into a large aqueduct, which lies about one third of a mile to the south, and the whole collected flow is thence carried to a pump-well, from which it is elevated, by two steam engines, 170 feet, into a reservoir located on the ridge, about five miles from Brooklyn City Hall, and from this reservoir thence distributed, by iron pipes, throughout the city. The bottom of the main aqueduct, where it begins at Hempstead Pond, is about $5\frac{9}{10}$ feet above average high tide, and descends, as it approaches the pump-well, at the rate of 6 inches to the mile, its whole length being a little more than $12\frac{1}{3}$ miles. The water-surface in the supply-ponds, when full, is from 8 to 15 feet above tide-water.

The material composing the entire district being sand, and the water, therefore, filtered, is very pure and cool. By the arrangement of branch aqueducts above described, each pond can be used or not, as may be wished, or the whole at once, so that any one of them may be repaired or cleaned without interfering with the delivery of the others.

It is hoped that the few facts developed in the following report will hereafter be confirmed and more thoroughly illustrated by the department into whose hands the charge of the works will ultimately fall. A thorough familiarity with the working of the system of supply already brought into service, and a full understanding both of the necessities and capabilities of the supply-basin, may prove of much use, not only to the city particularly benefitted, but to an intelligent development of the water resources of other districts.

THEODORE WESTON.

January, 1861.

REPORT.

JAMES P. KIRKWOOD, ESQ.,
Engineer Brooklyn Water Works.

MY DEAR SIR:—When, in November last, you desired me to ascertain the aggregate drainage area of the great basin whence the supply to our works is derived, I did not at once perceive what interesting questions were comprehended in this examination, nor how far faithful and continuous investigation was necessary to determine with accuracy the extent and peculiarity of this supply; and, though your restrictions did not admit of my undertaking a careful topographical and hydrometric survey of the district, I am convinced that, in prosecuting my inquiries somewhat further than you, perhaps, intended, you will not only see that the subject claimed this additional attention on our part, but will recognize the importance of collecting much more careful and elaborate data, from which to deduce any just and reliable results.

The constant attention which the construction of the Conduit Extension required from the available engineering force in the Company's service, prevented my taking up the drainage survey with any vigor until the 5th December last, when, joining the parties at my disposal, I was enabled, by uninterrupted and rapid surveillance, to complete most of the necessary field operations by the 1st January.

The interval which has since occurred has been consumed in preparing the accompanying drawings, and collecting such information as I judged would prove useful in explaining the character and capacity of our storage basin. If this interval has seemed to you unnecessarily prolonged, I trust the claims of other portions of the work upon our time will sufficiently excuse any apparent delay in submitting the results of our labors.

It was made the especial object of the survey,—

1st. To ascertain the actual periphery of the entire drainage district.

2d. To discover, as nearly as possible, the drainage limits of the different streams; and

3d. To determine the depth of the subterranean spring level below the surface.

As the readiest method of effecting these purposes in the rapid manner proposed, it was decided to follow up the numerous roads which cut the country in every direction, ascertaining their contour and neighboring topography, and invariably determining the water levels in all contiguous wells. Important valleys and streams which could not be thus reached were separately surveyed, and sufficiently far to learn their extent and direction.

The aggregate length of line so run amounted to 103¼ miles (the position and distribution of which is shown on the accompanying map).

The frequent intersection of these roads gave abundant opportunity of correcting and verifying all instrumental work, though no error of any importance was detected.

Some 25 miles of former surveys, by engineers previously employed on plans for the Water Works, and a portion of the profile of the Long Island Railway (between Hempstead and Jamaica), obtained from the office of the President of that Company, were appropriated and used in the construction of the map referred to in this report.

You will perceive that this map is intended to exhibit the extent and form of the separate basins, and to indicate, also, the length and bearing of the more important valleys and streams, both those contributing to our supply, and those unavailable to us. The contour of the spring-water surface is designated by the blue lines, which are traced on the map at intervals of 10 feet, between elevations of 15 and 50 feet above mean high tide-water.*

Profiles of the ground surface† and water bed at various points are also given, the portion of each which is colored blue indicating the height at which the spring water is found above datum base. The vertical lines on the profiles are the wells whose surfaces were ascertained by direct and careful measurement. Sections across the various supply ponds are added, in order to show the relative amount of muck deposit which had accumulated in each.

In looking over the map, your familiarity with the region there represented renders it hardly necessary for me to describe its ordinary features; it, however, may not be altogether improper to call your attention to some of its more prominent peculiarities in connection with the facts which have been elicited by our survey.

The northern limit of this basin is the well-defined chain of hills, which is a part of the great dividing line of Long Island; its southern boundary is the line of aqueduct, now in process of construction;* while its eastern and western extremities are terminated by lines nearly at right angles to the ridge. The annual precipitation of rain and snow upon the surface included in these limits is the sole source of its water supply.

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* Wherever levels are mentioned in this report, they are invariably to be referred to this datum-base used in the construction of our works.

† Elevations of the ground surface were taken at stations 200 feet apart.

This district, you will see, readily divides itself into two distinct portions:—

1st. The ridge and its slopes constituting about one twelfth the drainage area, having a compact and conglomerate soil, generally impermeable to water; and

2d. The table land lying at its base comprising the remainder, and having a soil of very porous and absorbent character.

The crest of the ridge is exceedingly irregular, and marked by depressions, whose substratum is often a bed of clay, which, collecting the surface water of many acres, holds it in the form of marshes, or small ponds, and allows it to escape only by slow filtration and evaporation. The southern slope of the ridge is more uniform, and, turning off most of the rain-fall upon the sand plain below, may be properly considered a part of our gathering ground.

As the shore line of the bay and this ridge converge toward the western extremity of the basin, we find the elevations of both plain and ridge proportionately diminishing toward that end, at an average rate of 12 feet per mile for the former, and 17½ feet per mile for the latter.* The face of the hill slope, as you will remember, is very steep, having a mean inclination of about one foot in six; from its base the table land thence falls towards the bay, at a varying rate of from 12 to 27 feet per mile.

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* The line of Conduit Extension lies so nearly at the natural edge of the basin, that I have considered it most convenient to assume it as our southern boundary.

The contour of this table is mostly even, and especially the eastern portion, which includes the Hempstead Plains; it becomes, however, more undulating as the Jamaica end is approached. We find a large proportion of it under cultivation, or open,—the forests, marshes, &c., not exceeding, probably, one seventh the entire area. After striking through the surface soil of shallow loam, a subsoil of clear, clean sand is universally found, whose constant character is undoubtedly preserved to a great depth beneath; and it is this great sand bed, the interstices between whose particles, up to a certain level, are filled with water, which constitutes the storage reservoir whence our supply is drawn.

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* While the ridge is some 11½ miles from tide-water at the east end of the basin, it is but 21,000 feet, or 4 miles, at the Jamaica end.

An elevation of 366 feet was reached upon the highest knoll of the Harbor hills, and one about 195 feet high north of Jamaica.

The subterranean surface of this reservoir conforms, in general, to the slope of the plain; but, as you would expect, it has much more regularity, and it is only at the southern extremity of the basin, where it lies very near the top of the ground, that any undulations are conspicuous. Occasional departures or variations from this general fact may, however, be explained by the probable existence of some impenetrable or disturbing stratum underneath; such, for instance, as you will observe in the Hyde Park profile at Herrick's Pond, and between Springfield and Brookfield in the Jericho turnpike; and, indeed, we are well warranted in ascribing them to this cause, since the excavations upon our works have revealed cases of similar geological peculiarity;* and we may presume that the regular level of storage would still be found below, at its proper elevation.

The uniformity of the water slope will be seen on comparing the grades of the separate profiles; thus, the rate

For Brookfield road is 2.4 feet per 1,000 feet.
" Springfield " " 2.6 " "
" Valley Stream " " 2.2 " "
" Rockville " " " 2.4 " "

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* The blue-clay bed found ten feet under the sand, at station 370 of Conduit Extension line, is a noticeable instance of this.

Indicating an extreme difference of but two feet per mile,—a condition so invariable that we may reason upon it with great certainty, while it affords the strongest testimony to the permanent character of the supply.

Having now recalled to you these more prominent features belonging to the region under consideration, I shall first direct your attention to the computed extent of various subdivisions of the district, and afterwards submit to you a few calculations, based upon what little information I have been able to collect, which may possibly assist in giving you some idea of the great capacity and constancy of our storage reservoir.

The drainage ground comprises a total area of 73.64 square miles, having an average length of about 12 miles, and a mean width of little more than 6. It may be subdivided into six portions:—

1st, Jamaica Creek and its tributaries,	10.88	sq. miles.
2d, Brookfield and Clear Stream Creeks,	8.87	"
3d, Valley Stream, or East Hook Creek Branch,	6.38	"
4th, Rockville Stream,	8.31	"
5th, Hempstead Creek,	25.79	"
	60.23	"
6th, Unappropriated streams,*	13.41	"
	73.64	"

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* The uncertain yield which is likely to be derived from the taps proposed in the sides of the aqueduct, and the difficulty of ascertaining the

The unappropriated portion, distinguished by the pink tint in the map, may be further subdivided, as follows :—

3.44	sq. miles,—	The region included between Conduit Extension and a line connecting the dams of supply ponds.	
5.60	"	Drainage of Springfield Valley.	
1.72	"	"	Valley Stream.
2.65	"	"	Foster's Brook and adjoining streams.
13.41	"		

It will be seen that 60.23 square miles, or 82 per cent. of the whole district, contributes to the supply ponds, while the remainder passes its waters off under our conduit, by the culverts provided, and they are thence carried to the sea.

Although the aggregate area, as stated, is probably very near the truth, the subdivisions, as shown in the map, must be regarded as more uncertain.

Were ours a mere surface drainage, the ridges between the streams would indicate truly the proper water-sheds; but since they are fed mostly from springs cropping out at various points in their course, all coming from the great level water-bed, whose regular surface was remarked above, the

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distance back from these deliveries at which the water-bed would be affected, has led me to reject altogether the region drained by them as a part of our gathering ground; it must, however, be quite small.

distance from the edge of the stream, where the influence of each ceases, is very difficult to conjecture.

Toward the mouths of the creeks, where the undulation of water follows the roll of the ground, we may determine the separations quite distinctly; but, as we approach their sources, where no such correspondence occurs, we must evidently locate them with great uncertainty; it is probable, indeed, that they merge into each other, very slight causes controlling the direction of the discharge. Between the base of the ridge and the heading of the streams, a large space intervenes, through which the water is very equally distributed, and which, in fact, can properly have no subterranean water-ridge.

The rate of fall of the stream does not commonly coincide with the rate of the underground water-slope,—the former being ordinarily about 10 feet per mile, while the latter, it was discovered above, preserves a uniform grade of 12¼. We, consequently, find the surface of the stream, as it approaches the southern edge of the basin, flowing above the storage surface; if, therefore, an adjoining brook is in a lower valley, it must apparently draw beyond the middle of the distance between the two. Brookfield Stream, for instance, is ponded at an elevation of 15.4 feet, while Clear Stream, adjacent, is but 10 ft.;

and we should, of course, infer that the latter would yield a larger percentage of water, in proportion to its length and importance, than the former; and, in some degree, it probably does, though it is much less than would be supposed, and not enough to materially affect the location of the divide.

With reference, then, to such conditions of discharge as our limited observations suggested, I have attempted to trace these water-ridges, indicating the surface-ridges, by lines of shading, and making them commonly the guide for the direction of the reservoir outline underneath.

If, now, we adopt these subdivisions, as estimated in the above areas, and compare each with the minimum flow of the drainage stream belonging to it, as given in your report of January, 1858, the following table is obtained:—

Districts.	Area drained, sq. miles.	Am't flow per day, N. Y. gals.	No. gals. per day per sq. mile.	No. gals. per day per acre.
Jamaica, ...	10.88	3,053,792	280,677	439
Brookfield and Cl. St...	8.87	2,617,536	295,100	461
Valley Stream,........	6.38	2,388,305	374,342	585
Rockville,.............	8.31	2,569,320	309,184	483
Hempstead,...........	25.79	7,651,321	296,677	463
Total and mean,.......	60.23	18,280,530	303,515	474
Unappropriated,........	13.41	4,063,230	303,515	474
Totals,................	73.64	22,343,760		

The unappropriated portion in the table, you will notice, is calculated to yield 4,063,230 gallons, —a quantity answering to the mean drainage per square mile of the other five districts.

It is seen, from the above schedule, that Valley Stream gives the highest rate per square mile, and Jamaica the lowest; while the others differ very little from each other. In the case of Valley Stream, it is not improbable that too little area is assigned its drainage territory; still, the flow of the stream is very direct and single, its only tributary uniting with it below our dam, and largely augmenting its volume. The circumstances of a free discharge of the bordering springs into its channel is very favorable, the ridge on either side being high, and the dip of the water-bed strong toward the stream.

In comparing, however, the form and features of the Jamaica district with the remainder of the basin, the *surface* character of its drainage is very apparent. Small brooks or arms shoot off in every direction, and the springs discharge feebly, the mean storage-head being but 12.9 feet above the plane of the full pond into which the whole water is delivered. Beaver Creek, which rises near the base of the main ridge, and is more immediately supplied by lateral springs, is its coolest, clearest, and most constant tributary, but yet does not contribute enough to give character to the pond, whose water is noticeably different from the others to the east. Our experience in its management also indicates that it is more readily and to a greater extent, affected by floods.

Of the remaining sub-districts, nothing in their physical conditions requires especial remark; the flow of their various drainage streams is quite similar and uniform, both in volume and quality.

Considering the resulting mean derived from the table as approximating the truth, we have a tolerably reliable calculating unit for the natural yield per square mile. If we assume, therefore, datum high tide plane as the bottom of our whole storage district, and neglect all absorbing capacity below that plane, by first determining the average height of saturation throughout the basin, and the amount of water which each cubic foot of sand will hold in its interstices, we may readily compute the whole quantity stored in the district.

From our map, the water surface is ascertained to have a mean level of $31\frac{6}{10}$ feet above the plane assumed; and, from the results of several experiments directed to this end (details of which are given in Table A, at the end), 0.30 is fixed as the storage space in each cubic foot of ordinary material composing the sand-bed. The area of the basin, then, being 73.64 square miles, or 2,052,670,816 square feet, by applying the units above our calculation gives us 19,459,319,335 cubic feet water in store,—a quantity sufficient to yield 20,000,000 gallons per day for nearly nineteen years, apart from the yearly addition by ordinary precipitation to its reserve. The same reasoning may manifestly be followed in estimating the reserve of each sub-area, new depths being found for every separate district.

The subjoined table, in which I have computed the depths above the plane of each pond surface when full, will give you their relative storage capacities above those levels:—

DISTRICT.	Level of full pond	Surface of storage above full pond.	Area of district.	Min. daily flow.	Amount held in store.	No. days reserve.
	Ft.	Ft.	Sq. feet.	Cub. feet.	Cub. feet.	
Jamaica, ...	8.0	12.9	299,570,000	391,010	1,162,032,030	2,792
Brookfield, ...	15.4					
Clear Stream,...	10.0					
Valley Stream,....	12.8	20.3	177,750,000	305,801	1,083,564,000	3,543
Rockville, ...	13.0	34.4	231,625,000	328,978	2,393,844,375	7,276
Hempstead, ...	10.6	38.4	719,265,000	979,683	6,866,754,472	7,009

So large a reserve as is here indicated for each, must prevent the flow of any of the streams from becoming seriously diminished by drought; nor, probably, would the stored amounts vary much from year to year, the extra precipitation passing off by increased discharge through the streams.

We may now, by taking the mean rain-fall upon the general district, judge still further of its capacity and constancy, and discover how much may be drawn away without injury to this reserve.

Estimating the average precipitation at $42\frac{55}{100}$ inches per year on each square foot of area,* we find that it would have required upwards of three years to have filled the basin without any waste occurring, either from evaporation, vegetable absorption, or by discharge through the springs and water courses; and that, allowing for these natural losses, it would have taken not less than twelve years to bring the reserve up to its present level.

We see, consequently, that the small variations of a season's, or even a year's, rain-fall can affect the reserve height but slightly, compelling us to recognize without hesitation the certainty and permanency of our supply.†

Being convinced, then, of its great capacity, it becomes interesting to know what proportion of the annual rain-fall is passed off through our supply-streams, and made available to us by the present location of the works. And though we have made no experiments sufficiently definite to determine the evaporation, or vegetable absorption in our own district, we still have enough data to compute the total percentage of loss, and thence judge, from the

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* This mean is made up from the three tables (B, C, and D) appended. The Jamaica record, you will perceive, is thrown out as entirely unreliable.

† The general truth here stated, respecting the constancy of the water-surface in the mean area of the basin, admits, however, of some qualification when applied to its southern or discharging edge. As before remarked, the level of this region of the reserve lies very near the surface of the ground,

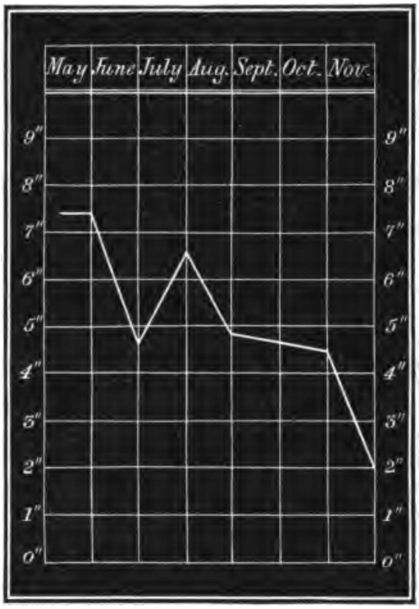
and the rain-fall, readily penetrating to it, produces fluctuations in its height, corresponding, in some degree, to the variations of precipitation.

The following table of comparative elevation of several pits and wells near the line of our works, taken at different periods, to which I have attached a profile of rain-fall for corresponding periods, will illustrate this fact to some extent:—

	WELLS.	Elevations above tide-base.					Extreme fluctuations.
		June 27th, 1857.	Sept. 14th, 1857.	Oct. 3d, 1857.	Nov. 23d, 1857.	Feb. 29th, 1860.	
		Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
Earth, covering from 2 to 5 feet deep,.........	No. 1,	2.94		1.52	2.35	3.03	1.51
	" 2,	3.64			2.63	3.38	1.01
	" 3,	7.70		4.81	6.18	7.31	2.89
	" 4,	6.72			5.40	5.97	1.32
Earth-covering from 8 to 12 feet deep,........	" 5,	6.08		5.96	5.91		0.17
	" 6,		1.35		1.36	1.70	0.35
	" 7,		5.66	5.72	6.03		0.37
	" 8,			7.17	7.44	7.31	0.27

A comparison of the table and profile would indicate that, though the rain-fall of the Summer months considerably exceeded that of the Autumn, yet the surface of the water-bed sunk until cool, unevaporating weather set common experience in other regions, what proportion properly belongs to these two.

In your report of 1858, you collected some information relating to surface-evaporation, to which I have been unable to add anything more reliable or extended, beyond the mere general inferences which



Profile of Rain-fall from May to November, 1857 (inclusive).

in; and we must presume, therefore, that nearly all the precipitation of the hot months was dissipated before it reached the under-ground reserve.

You will observe, also, that the deeper wells (those highest above datum) were generally more constant,—the extreme fluctuation of Nos. 5, 6, 7, and 8 being small beside Nos. 1, 2, 3, and 4, which have much less earth covering.

are inapplicable to special districts like our own. Mr. Stirrat, however, whom I think you quote, in evidence before the Parliamentary Committee of 1850, states that, while Mr. Thom had previously reckoned on a loss of 66 per cent. of the annual rain-fall in the Paisley district, subsequent experience had proved that it was but 33 in those gathering grounds,—an amount much below the common estimate. Mr. Donaldson, before the same committee, affirms that, at Richmond Park, but 10 out of 25 inches fall was available; in other words, that 60 per cent. was lost. Both these districts were largely drained by the subsoil system.

Mr. Ellet, in a report rendered Sept. 11th, 1849, and published among the Smithsonian contributions, as the result of careful observation throughout the feeding district of the upper Ohio, states the mean loss to be 60 per cent.; and I think it will be found that the most intelligent estimates rather exceed than fall below this figure. We must expect, consequently, in our sand country, to calculate for at least an equal amount, and, as the following computations would suggest, possibly still more.

If the average flow of any one of our streams be deducted from the mean annual rain-fall upon the districts named by it, we have at once the comparative available percentage. I have fixed the average flow, in the absence of any continuous record, at two thirds more than the minimum set down in your report above referred to; and though you would presume this to be large, you will perceive, from the table below, that the actual loss in the district is so great that considerable differences in the daily discharge of the streams would not especially affect the average results:

DISTRICTS.	Area drained.	Total yearly rain.	Min. flow per day.	Ave. flow per day.	Total yearly flow.	Per centum of loss.
	Sq. feet.	Cub. feet.	Cub. ft.	Cub. ft.	Cub. ft.	
Jamaica, ...	299,570,000	1,060,477,800	891,010	652,000	238,080,000	77 8-10
Brookf'd & Cl. St.	246,155,000	871,838,700	835,280	558,800	208,962,000	76 6-10
Valley Stream,...	177,750,000	629,235,000	805,801	510,100	186,150,000	70 4-10
Rockville, ...	231,625,000	819,952,500	828,978	548,500	200,202,500	75 6-10
Hempstead, ...	719,265,000	2,546,198,100	979,683	1,632,650	595,917,250	76 6-10
Total and mean,..		5,927,252,100	2,340,752	3,902,050		75 4-10

These percentages are the losses in each particular sub-district; but, to reach the true mean for the whole basin, we must add to that given in the table the amount due upon the unappropriated area, which is found to be 1,323,960,000 cubic feet,—increasing, consequently, the total mean to 78 per cent.

A very considerable proportion of this must be credited to the waste from springs cropping out below the line of our supply reservoirs, but which are fed from the same storage. By gaugings made on two streams (Watts and Brookfield), detailed reports of which I returned to you in August last, and which you will find in the Appendix (marked E and F), the increased volume for each, at somewhat less than a mile below the city's present ownership, was discovered to be $\frac{5}{14}$ more at a time of minimum flow. This ratio would undoubtedly be reduced during a period of maximum or average discharge, when no additional want could be felt, and need not, therefore, be considered. At the above rate, then, 15 per cent. of the precipitation would be due to this subterranean loss,—leaving, therefore, 63 per cent. to be divided between the necessities of vegetable life and the waste of evaporation.

The average daily flow, it is seen from the statement in the table just given, yields us upwards of 30,000,000 gallons, which, could we avail ourselves of, the 15 per cent. here indicated would give us a constant delivery of 50,000,000 gallons per day, and, with the additional $13\frac{41}{100}$ square miles of our unappropriated sub-district, a further increase to 61,000,000, or a minimum equal to 40,000,000 gallons, irrespective of the storage reserve,—all which may be wholly procured from the territory lying above the line of Conduit Extension. This, then, may be regarded as the natural and available quantity within the reach of our works, as they are now located and constructed; and I have, therefore, directed my inquiries almost exclusively to the reliable determination of the yield of this region.

But, it will be perceived that the whole district lying between this line and the shore of Jamaica bay has not, thus far, entered into my estimate. It must, however, deliver proportionally a much larger quantity than any other; since, in addition to the regular rain precipitation upon its surface, which, of course, would equal the amount per square mile assumed for the main district, it yields, also, all the unestimated surplus that may have come down to it from the higher grounds which we have been considering. I have attempted, therefore, to ascertain this important increment, in a general way, by noting the changes in the specific gravity of water along the shore of the bay at different states of the tide, and afterward roughly computing a mean percentage for the daily infusion of fresh water coming from our entire drainage district, and subsequently deducting the known yield of the streams.

A carefully tested hydrometer was used for this purpose. The result of these observations is given in the table (marked H) in the Appendix,—each recorded experiment, it may be remarked, being the average of a number of trials.

The shore edge bounding our drainage district has a length of rather more than four miles on

Jamaica bay, and about three and one half on Hempstead bay. At various points on this line the several streams which at present supply our works have their mouths. Abandoning now any attempt at a calculation of the Hempstead line, upon which no experiment has been made, we find that Jamaica bay has a total water area of about 23½ square miles, with an average water depth, at low tide, of about four feet, giving us 2,995,110,400 cubic feet of water. Estimating, from the table of observations, the fresh water infusion to be 10 per cent. of the whole quantity, we have 295,511,040 cubic feet as the amount in store in the whole bay at low water, when the springs and streams are discharging most abundantly. Assuming one fourth of this quantity only as coming from our supply district, there remains 73,827,760 cubic feet. On the supposition that the waters of the bay are not wholly renewed oftener than thrice per month, $\frac{1}{10}$ of the above quantity would give us the whole daily fresh-water delivery, equal to 7,382,776 cubic feet. The minimum yield of the streams of all the territory north of Conduit Extension, as stated in the early part of this report, is 22,343,760 gallons, or 2,860,920 cubic feet; of which, however, the flow of Rockville and Hempstead Creeks, with their tributaries, is to be deducted, since they empty into

Hempstead bay,—leaving, therefore, 1,552,010 cubic feet to be taken from the whole computed discharge into Jamaica bay, and which will then be 5,830,766 cubic feet, or 47,229,000 gallons. The whole district comprised between the Conduit Extension line and the shores of the bays amounts to nearly $16\frac{42}{100}$ square miles, $9\frac{50}{100}$ of which, discharging into Jamaica Bay, delivers the above minimum of 47,229,000 gallons,—at a rate, consequently, of 4,971,400 gallons per square mile. The remaining portion of $6\frac{92}{100}$ square miles, discharging into Hempstead bay under exactly analogous peculiarities, would afford, therefore, at the same calculation per square mile, a further amount of 34,402,088 gallons.

Upon collecting all these above quantities, and adding their different results, we reach the following summary:—

	Sq. miles.	N. Y. gallons.
1. For the available water delivery into the present works, as ascertained by careful gauging, we have, for......	73.64	22,343,760
2. For drainage of surplus water into Jamaica bay, as ascertained by Hydrometer,......................	9.50	47,229,000
3. For drainage of surplus water into Hempstead bay, by comparative estimate,......................	6.92	34,402,088
Totals,......................	90.06	103,974,760

It may very properly be urged, that the data upon which items Nos. 2 and 3 have been computed are entirely vague and insufficient, and would probably be largely affected by many natural contingencies which have not been investigated or alluded to. It may be seen, however, if we return to an examination of the more reliable figures gathered from the facts relating to the district which we have already appropriated, that it was there found that a loss of 78 per cent. of the annual precipitation was very satisfactorily determined. This loss, then, carrying out that computation, would amount to 79,218,828 gallons, and, added to the quantity actually gauged, viz., 22,343,760 gallons, gives us a daily delivery of 101,562,588 gallons. If, also, to this be added the same rate of precipitation upon the shore district, amounting to 23,345,400 gallons more, we have a grand total precipitation, over the whole $90\frac{6}{100}$ square miles, of 124,907,988 gallons' equivalent,—allowing us, you will perceive, 21,000,000 gallons daily surplus, or nearly 20 per cent. above my hydrometric estimate, which we may credit to the necessary vegetable waste, and to the evaporation. How this evaporation might be lessened by careful subsoil drainage,* and thus a

* It seems to be commonly conceded that nearly the whole rain-fall, during the months of July, August, and September, is evaporated before

still further contribution to the resources of our supply-basin secured, I do not propose to inquire, my object having been simply to call your attention to the general capacity of the basin under circumstances of its present natural yield.

But it is worth while to consider, in case the city ever contemplates an extension of her works, whether some way could not be devised for collecting and securing a portion of the great waste which has been shown to occur, and thus avoid the larger outlay likely to be needed in the purchase and adaptation of new territory to the purposes of increased supply.

In view of such a necessity, the value of a thorough and continuous series of observations and experiments becomes very apparent, and the propriety of instituting some system of this kind will undoubtedly suggest itself to you.

I have appended tables of rain-fall for Fort Hamilton, Fort Columbus, and Flatbush, with profiles of various monthly and yearly averages, whose respective headings will sufficiently explain them.

I have not thought it proper, in the limited range of this investigation, to submit any facts relating to the character and quality of the water

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reaching the underground storage; the springs and streams, consequently, during this time, draw wholly upon the reserve.

from the different streams, since it must evidently be considered a very distinct and special branch of inquiry.

It gives me great pleasure to acknowledge the important assistance of Messrs. Martin & Whitman in the surveys, and of Mr. Williams in the accompanying map.

Very truly,

THEODORE WESTON.

APPENDIX.

APPENDIX.

[A.]

EXPERIMENTS MADE TO DETERMINE ABSORBING CAPACITY OF SAND AND GRAVEL.

The experiments were made in a tight box, containing one cubic foot, the box being first filled with the sand, and water afterward added.

No. 1.	Sand loosely thrown in,	0.360	cub. ft. water.
“ 2.	“ “ “	0.350	“ “
“ 3.	“ “ “	0.310	“ “
“ 4.	“ “ “	0.325	“ “
“ 5.	“ “ “	0.356	“ “
“ 6.	“ “ “	0.372	“ “
“ 7.	“ tamped with shovel,	0.270	“ “
“ 8.	“ rammed very closely,	0.230	“ “
“ 9.	Coarse sand, loosely thrown in,	0.320	“ “
“ 10.	“ “ “ “	0.328	“ “
“ 11.	“ “ “ “	0.340	“ “
“ 12.	Sand and gravel, loosely thrown in,	0.260	“ “
“ 13.	“ “ “ “	0.275	“ “
“ 14.	“ “ “ “	0.323	“ “
“ 15.	“ “ “ “	0.275	“ “

No. 16.	Gravel, clear, loosely thrown in,				....0.360	cub. ft.	water.
“ 17.	“	“	“	“	....0.358	“	“
“ 18.	“	“	“	“	....0.350	“	“
“ 19.	“	“	“	“	....0.345	“	“
“ 20.	“	“	“	“	....0.350	“	“
“ 21.	“	“	“	“	....0.363	“	“
“ 22.	Broken stone, specification size,*				...0.520	“	“

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* Viz., 8 cubic inches.

[B.]

RAIN RECORD FOR FLATBUSH.

YEAR.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	SPRING	SUM'R.	AUT'M.	WINT'R	YEAR.
1826......	0.47	1.46	3.66	2.03	0.06	8.40	3.77	7.95	3.09	8.54	2.95	2.51	5.75	20.12	14.58	4.44	44.89
1827......	2.45	4.50	2.05	5.65	3.45	3.68	3.58	5.47	3.78	4.10	6.05	3.51	11.15	12.73	13.93	10.46	48.27
1828......	3.02	3.25	4.50	4.33	4.80	2.55	3.73	1.97	6.85	0.96	8.73	0.45	13.63	8.25	16.54	6.72	45.14
1829......	4.48	5.64	4.17	5.36	3.90	3.38	2.35	4.84	3.16	4.41	4.96	1.89	13.43	10.57	12.53	12.01	48.54
1830......	2.87	2.07	8.08	3.30	3.77	4.68	5.49	2.49	1.33	4.78	6.69	7.92	15.15	12.66	12.80	12.86	53.47
1831......	4.72	3.46	4.24	5.98	2.36	1.48	6.17	2.55	3.14	4.47	2.02	1.93	12.58	10.20	19.63	10.11	42.52
1832......	5.55	2.76	0.83	3.40	4.65	0.97	5.31	5.91	1.91	3.06	3.63	5.56	8.88	12.19	8.60	13.87	43.54
1833......	3.18	1.00	3.30	1.87	5.70	4.87	3.63	3.68	2.94	8.52	2.39	5.60	10.87	12.18	13.85	9.78	44.68
1834......	2.22	2.37	1.62	3.21	4.88	7.25	4.54	0.90	3.05	2.70	3.83	2.90	9.71	12.69	9.58	7.49	39.47
1835......	2.65	1.21	4.71	6.22	1.76	3.25	5.13	2.84	1.27	2.11	3.16	3.71	12.69	11.22	6.54	7.57	38.02
1836......	7.51	4.06	2.50	4.01	1.38	8.55	2.50	2.31	1.66	2.74	2.75	3.92	7.89	13.36	6.15	15.49	43.89
1837......	1.84	2.83	5.92	3.23	4.29	3.45	2.98	3.15	1.76	1.01	1.65	2.55	13.44	9.58	4.42	7.22	34.66
1838......	2.22	1.50	3.42	3.07	4.54	4.90	2.19	1.74	8.22	3.98	3.91	1.42	11.03	8.83	16.11	5.14	41.11
1839......	1.82	2.52	1.88	3.64	5.74	4.84	2.75	3.91	3.09	1.99	3.88	6.84	11.26	11.50	8.96	11.18	42.90
1840......	2.00	2.84	2.58	4.95	2.82	1.90	1.10	3.71	1.84	4.62	3.33	4.26	10.35	6.71	9.79	9.10	35.95
1841......	6.70	1.53	4.77	6.77	3.01	4.56	2.85	5.50	1.73	4.50	5.02	5.18	14.55	12.91	11.25	13.41	52.12
1842......	1.34	4.13	2.08	4.58	4.63	3.25	6.17	5.86	2.82	4.17	3.50	4.51	11.29	15.28	10.49	9.98	47.04
1843......	1.13	2.79	4.59	5.21	1.59	1.75	1.96	15.76	2.78	4.87	3.88	3.88	11.39	19.47	11.53	7.80	50.19
1844......	3.66	1.50	4.37	0.53	3.83	3.48	5.42	3.71	2.75	4.22	1.79	2.81	8.73	12.61	8.76	7.97	38.07
1845......	3.84	4.45	2.50	1.04	1.55	3.36	1.67	3.82	2.65	1.92	3.08	2.81	5.09	8.30	7.65	11.10	32.14
1846......	4.16	3.56	2.78	3.01	7.18	1.12	5.75	4.10	0.09	1.72	7.12	3.41	12.97	10.97	9.94	11.13	45.00
1847......	3.54	5.41	5.13	0.82	1.69	5.51	2.58	2.40	10.65	1.79	3.08	3.33	7.64	10.49	15.52	11.28	33.93
1848......	1.80	1.51	2.12	0.89	5.27	5.19	3.00	1.00	2.15	4.09	1.85	4.54	8.28	9.19	8.09	7.85	33.41
1849......	0.55	2.23	5.07	0.80	3.76	0.77	2.15	3.99	0.98	6.26	1.88	4.03	9.63	6.91	9.12	6.81	32.47
1850......	5.70	3.33	3.75	2.68	7.21	2.53	4.43	7.43	4.19	1.85	1.10	4.08	13.64	14.49	7.14	13.11	48.38
1851......	1.63	4.24	3.34	7.02	4.00	2.00	3.85	3.23	1.06	4.47	3.98	2.00	14.36	9.08	9.51	7.87	40.82
1852......	2.47	3.27	4.34	5.25	2.40	2.49	1.77	9.25	2.01	2.52	6.24	5.73	11.99	13.51	10.77	11.47	47.74
1853......	2.63	4.29	3.85	4.04	5.01	5.68	5.74	5.96	5.20	3.66	4.00	2.38	12.90	17.38	12.86	9.30	52.44
1854......	2.83	5.41	1.62	11.60	5.34	2.16	1.69	0.85	3.23	2.05	6.25	3.65	18.56	4.70	12.53	11.89	47.68
1855......	4.55	3.72	2.12	2.20	4.98	5.50	5.88	2.62	2.95	7.08	3.04	6.20	9.31	14.90	13.07	14.47	51.75
1856......	4.13	0.98	2.13	2.69	4.18	3.80	3.24	0.84	3.84	0.88	2.68	3.32	9.00	7.88	7.40	8.43	32.71
1857......	1.99	1.56	2.14	7.50	6.13	4.57	6.37	3.81	3.48	3.88	1.90	4.94	15.77	14.75	9.26	8.49	48.27
Av'ge 32 yrs.	3.24	2.98	3.44	3.97	3.93	3.78	3.74	4.16	3.11	3.68	3.76	3.80	11.34	11.74	10.90	9.87	43.16

[C.]

RECORD OF RAIN-FALL AT FORT HAMILTON, N. Y.

YEAR.	Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	SPRING	SUM'R.	AUT'M.	WINT'R	YEAR.
1839......	1.80	2.72	1.90	3.34	6.22	6.41	2.80	5.33	4.74	2.35	4.80	8.70	11.46	14.54	11.69	13.22	51.11
1840......	2.50	2.80		4.85	3.38	5.11	4.55	6.20	1.72					15.86			
1843......	0.70	1.90	4.20	5.70	1.32	1.67	1.88	14.05	3.75	4.10	1.70	3.21	11.22	17.69	9.55	5.81	44.18
1844......	2.97	0.93	4.33	0.52	2.80	2.32	4.87	1.72	4.30	3.78	2.05	2.05	7.65	8.91	10.13	5.95	32.64
1845......	4.26	5.70	2.21	1.00	1.47	3.60	1.95	4.48	2.28	1.76	2.95	3.45	4.68	10.13	6.99	13.41	35.21
1846......	5.15	5.55	2.82	2.40	9.84	2.14	7.09	4.34	0.20	1.58	8.90	2.68	15.06	13.57	10.68	13.38	52.69
1847......	5.04	7.05	5.04	0.71	1.63	8.37	4.32	3.30	10.60	4.25	5.20	7.18	7.38	15.99	20.05	19.27	62.69
1848......	2.20	1.17	1.84	1.75	9.32	5.19	1.80	0.94	1.65	2.95	1.82	2.50	12.91	7.93	6.42	8.87	36.13
1849......	0.44	2.12	5.11	0.62	3.75	0.82	2.76	3.01	2.84	4.50	1.45	2.43	9.38	6.59	8.79	4.99	29.75
1850......	4.69	1.74	5.55	1.44	6.74	2.11	3.68	6.16	4.20	1.83	1.98	5.77	13.73	11.95	8.01	12.20	45.89
1851......	2.39	4 44	3.88	5.32	2.88	1.68	3.29	2.64	1.31	2.99	4.39	2.66	12.08	7.61	8.69	9.49	37.87
1852......	1.94	2.27	4.11	6.06	3.20	2.80	2.64	4.46	1.99	2.25	4.14	3.80	13.37	9.90	8.38	8.01	39.66
1853......	4.58	7.24	5.79	4.78	6.02	4.42	5.83	5.23	3.75	2.73	3.71	1.16	16.59	15.48	10.19	12.98	55.24
1854......	3.03	4.45	0.65	9.58	6.09	4.25	2.23	0.26	3.50	1.19	5.70	3.35	16.32	6.74	10.39	10.85	44.30
Mean 14 yrs.	2.98	3.57	3.65	3.42	4.62	3.63	3.55	4.44	3.38	2.80	3.75	3.84	11.69	11.64	9.93	10.39	43.65

[D.]

FORT COLUMBUS.

YEAR.	Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	SPRING	SUM'R.	AUT'M.	WINT'R	YEAR.
1836......	1.09	2.01	1.31	2.60	0.63	6.46	1.44	2.37	3.40	2.00	1.90	2.30	4.60	10.27	7.30	5.40	27.57
1837......	2.70	3.70	8.20	7.50	9.50	8.50	5.90	6.30	2.10	2.11	2.90	6.10	25.20	20.70	7.11	12.50	65.51
1838......	2.93	3.70	4.10	2.50	3.99	3.12	1.83	4.79	4.96	3.64	3.10	2.24	10.59	9.74	11.70	9.87	41.90
1839......	0.69	2.05	2.46	3.35	8.37	4.94	1.35	4.92	3.59	1.45	2.19	7.61	14.18	11.21	7.23	10.35	42.97
1840......	1.84	1.84	2.95	2.03	2.39	2.40	1.80	4.25	1.84	4.59	2.90	1.00	7.34	8.45	9.33	4.68	29.80
1841......	5.30	0.80	2.35	3.93	3.95	4.65	4.90	2.50	2.90	4.40	3.70	2.70	10.23	12.05	11.00	8.80	42.08
1842......	1.07	2.85	1.25	3.60	3.60	3.30	3.80	2.81	2.10	4.30	1.80	3.50	8.45	8.91	8.20	7.42	32.98
1843......	1.00	2.31	2.13	2.14	2.14	0.76	1.64	15.26	3.06	5.91	2.82	3.34	5.27	17.66	11.79	6.65	41.37
1844......	2.66	1.03	4.50	0.55	0.55	2.37	6.00	2.73	4.50	4.08	1.73	2.82	8.46	11.10	10.31	6.51	36.38
1845......	4.87	3.22	3.33	1.22	1.75	3.70	1.75	3.21	2.62	2.50	3.40	2.51	6.30	8.66	8.52	10.60	34.08
1846......	3.92	3.01	3.82	4.01	9.70	1.39	6.01	3.88	0.48	1.34	8.36	2.99	17.53	11.28	10.18	9.92	48.91
1847......	4.62	5.74	8.48	1.53	2.18	6.78	1.62	6.93	12.20	2.13	6.29	6.35	12.19	15.33	20.62	16.71	64.85
1848......	1.75	1.68	2.23	1.16	7.28	4.56	2.64	1.41	1.87	6.61	1.59	4.02	10.67	8.61	10.07	7.45	36.80
1849......	0.61	2.26	4.87	0.62	3.47	0.78	1.43	4.63	1.55	5.63	1.88	4.01	8.96	6.84	9.06	6.88	31.14
1850......	5.57	2.64	4.64	2.72	9.20	3.07	3.92	7.21	4.71	3.16	2.33	5.36	16.56	14.20	10.20	13.57	54.53
1851......	1.46	4.50	1.70	6.94	4.73	0.90	4.72	3.47	1.26	2.95	4.53	3.72	13.37	9.18	8.74	8.68	39.97
1852......	2.92	3.08	4.43	4.74	2.24	2.11	3.25	6.20	2.29	2.06	6.07	4.45	11.41	11.56	10.42	10.45	43.84
1853......	4.14	4.98	2.03	3.32	5.80	4.80	4.40	5.50	5.49	3.90	6.80	1.04	11.15	14.70	16.19	10.16	52.20
1854......	2.60	4.00	0.70	8.80	7.70	2.20	1.90	1.03	1.90	1.80	3.95	8.60	17.20	5.13	7.65	15.20	45.18
Average....	2.78	2.92	3.44	3.33	4.78	3.46	3.17	4.70	3.31	3.40	3.59	3.93	11.55	11.33	10.30	9.63	42.23

[E.]

JAMAICA, *July* 28*th*, 1859.

J. P. KIRKWOOD, ESQ.

Dear Sir:—In obedience to your wishes, I have hastily endeavored to ascertain the additional flow of water between our Valley-Stream Reservoir and Watts' Pond, next below on the same stream; and that, also, between Brookfield Reservoir and Conselyea's Pond, next below.

Of the first case, I am sorry to say that, owing to the irregular and capricious use of water in the mills above on this stream, I found it impossible to obtain any reliable gaugings in the short time at my disposal, and have, therefore, thought it best to omit the record.

For the latter, however, the subjoined table will indicate to you the comparative increase of which you wished to assure yourself; the gaugings were taken under favorable circumstances of flow, and, as you will perceive, show a very uniform register.

Brookfield (Simonson's) Stream receives no noticeable accession from any branch or tributary between the two ponds under observation; but the whole intervening ground on either side of it is full of springs, which discharge into the current very freely. The distance from Brookfield Reservoir to Conselyea's Pond is 5,200 feet.

The method of gauging was as follows: At Brookfield Reservoir our present weir of masonry was used, and the depth of flow on the over-fall measured a few feet back in still water, by a hook-gauge, applied to a fixed graduated rod. This weir has a width of $14\frac{44}{100}$ feet, and, as you will see by the annexed table, the depth of flow over it did not reach two inches; on applying Mr. Francis' formula, therefore, to the calculations, inasmuch as its conditions were not completely filled, I have modified it slightly to suit this particular case. No perceptible contraction occurring, I have neglected the deduction for effective length, 0.2 H, and corrected the constant 3.33,—the formula, as used, standing thus:—

$$Q=3.315\sqrt{H^3}(L).$$

At Conselyea's, however, a weir was inserted in the mill-sluice, following closely the form of construction recommended by Mr. Francis. The width was made $2\frac{16}{100}$ feet, the height of fall nearly four feet, the stream uniformly flowing more than eight inches deep over it,—securing us, consequently, a very accurate application of the regular formula,

$$Q=3.33\sqrt{H^3}(L-0.2\ H).$$

The gaugings were made simultaneously at both ponds every three hours, on the 26th, and every hour, from 9 A. M. to 6 P. M., on the 27th,—the full flow of the stream being reached about 2 P. M. of the second day, and continuing quite regular up to the time our observations ceased.

The increment, you will discover, amounts to about one and a half millions of gallons,—a very important and suggestive difference.

In the case of Valley Stream, I should be glad to repeat my observations with more care, and sufficiently long to ascertain the analogous increase which comes into that stream below our reservoir.

I remain, very respectfully,
Your servant,
THEODORE WESTON.

[E.]

TABLE SHOWING ADDITIONAL FLOW OF WATER ON BROOKFIELD CREEK, BETWEEN BROOKFIELD AND CONSELYEA'S PONDS.

BROOKFIELD POND. Weir 14.44 feet wide.					CONSELYEA'S POND. Weir 2.16 feet wide.				
DATE.	Hour.	Depth of flow, in feet.	Cubic Feet per second.	N. Y. Gallons in 24 hours.	DATE.	Hour.	Depth of flow, in feet.	Cubic Feet per second.	N. Y. Gallons in 24 hours.
		Feet.	Cub. ft.	N.Y. gals.			Feet.		N.Y. gals.
July 26...	12 M.	0.125	2.1158	1,461,101	July 26...	12 M.	0.335		
" " ..	3 P.M.	0.125	2.1158	1,461,101	" " ..	3 P.M.	0.440		1,362,510
" " ..	6 "	0.130	2.2402	1,511,516	" " ..	6 "	0.490		1,593,872
" 27...	9 A.M.	0.135	2.3742	1,601,936	" 27...	9 A.M.	0.695		2,638,164
" " ..	10 "	0.130	2.2402	1,511,516	" " ..	10 "	0.715		2,747,000
" " ..	11 "	0.135	2.3742	1,601,936	" " ..	11 "	0.715		2,747,000
" " ..	12 M.	0.135	2.3742	1,601,936	" " ..	12 M.	0.720		2,774,241
" " ..	1 P.M.	0.135	2.3742	1,601,936	" " ..	1 P.M.	0.720		2,774,241
" " ..	2 "	0.130	2.2402	1,511,516	" " ..	2 "	0.725		2,801,925
" " ..	3 "	0.130	2.2402	1,511,516	" " ..	3 "	0.730		2,829,583
" " ..	4 "	0.125	2.1158	1,461,101	" " ..	4 "	0.735		2,860,819
" " ..	5 "	0.130	2.2402	1,511,516	" " ..	5 "	0.735		2,860,819
" " ..	6 "	0.130	2.2402	1,511,516	" " ..	6 "	0.735		2,860,819
FORMULA.—$Q=3.33\sqrt{H^3}\,(L-0.2H)$.					FORMULA.—$Q=3.315\sqrt{H^3}\,(L)$.				

[F.]

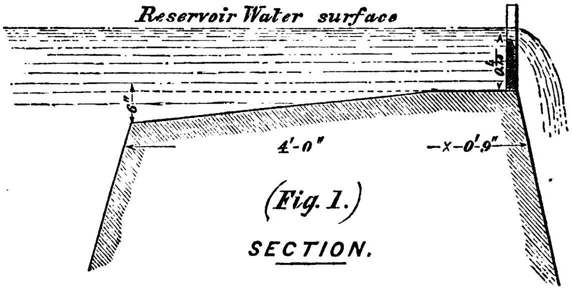
Jamaica, *August* 23*d*, 1859.

My Dear Sir:—Since the date of my last statement to you concerning the relative increase of flow between the Valley-Stream Reservoir and Watts' Pond, below, on the same stream, I have regauged the delivery at both these points with some care, the result of which is appended in the accompanying record.

Having effectually removed all causes of irregularity that were discoverable, I continued the gaugings for some time after a uniform flow was reached, in order to assure myself, beyond a doubt, of a correct determination of the difference sought to be established.

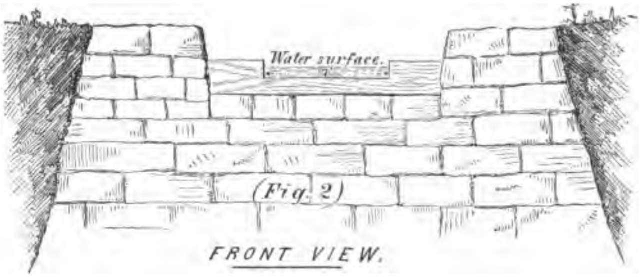
The weirs used at the present trial were constructed somewhat differently from those first employed.

At Valley-Stream Reservoir, the present over-fall of masonry was narrowed by a breast-board, in which a weir, 7 feet wide, was cut out. It was placed on the outer edge of the masonry, and had a height of $\frac{40}{100}$ ft. above it. The arrangement will be understood from Figs. 1 and 2.



(Fig. 1.)

SECTION.



FRONT VIEW.

The water was retained in the reservoir until its head had reached $\frac{245}{1000}$ ft. on the weir,—at which point, as will be seen by the table, our observations commenced.

At Watts' Pond, below, the weir was placed in a rectangular sluice-way which belongs to the mill on that pond. This sluice-way was about 15 feet long, with a width of $3\frac{645}{1000}$ feet. The over-fall bar was made the entire width of the sluice-way, and inserted about 3 feet from its lower end.

Our observations began at 11 A. M., August 4th, and ended at 6 P. M., August 8th. From August 4th until 6 A. M. of the 8th, the gaugings were noted every two hours; and from 6 A. M. to 6 P. M., on the 8th, they were registered every hour. As in the former trial, a hook-gauge was used, and readings taken simultaneously at both ponds.

The flow, it will be noticed, increased quite uniformly up to 2 P. M., August 5th, at which time a sudden rise occurred in the reservoir, owing to the discharge of the waters in the mill-ponds above,—which, however, from this date until the conclusion of our gaugings, were placed under our control. The natural delivery of the stream seems to have been reached about 12 M., August 8th, the observations showing very little variation after that hour.

In applying the formulas for calculation, I have considered that neither weir followed precisely the conditions of construction required in the correct use of any of the ordinary forms. I have, therefore, adopted one most applicable to both weirs, correcting them by a mean coefficient suited more particularly to each case.

In Castel's experiments, at Toulouse, a sluice $19\frac{68}{100}$ feet long and $2\frac{427}{1000}$ feet wide was used, and a weir of equal width placed at the lower end, with a depth, from the crest of the over-fall to the bottom of the sluice-way, of $\frac{557}{1000}$ ft. With a head of $\frac{26}{100}$ ft., or a little less than one half the height of the over-fall bar, he obtained a coefficient 0.662; and, upon either increasing or diminishing this head, very little variation followed.

The circumstances of this experiment are so closely analogous to our own case at Watts' Pond, that I have adopted the coefficient so obtained, and applied it in the formula,

$$Q=5.35mlH\sqrt{H}\,; \text{ where}$$

Q=Quantity, in cubic feet, discharged per second.
$5.35=\frac{2}{3}\sqrt{gh}$=Theoretical discharge.
l=Width of Weir=$3\frac{645}{1000}$ ft.
m=Correction for discharge=0.665.

At Valley-Stream Reservoir I have used the same form, but l in this case =7 ft., and m=0.600 (which includes error for contraction). This value of m is derived from the results of Blackwell's investigations on the Avon Canal. The width of his weir was 6 feet, our own being 7 feet. In his case, the depth of water, for some little distance back from the over-fall, was reduced to 18@20 inches, by a submerged course of masonry. In our own we have a corresponding depth of from 13@18 inches for a distance of 4′ 9″ back. He placed his over-fall on the outer line of the dam; the position of our own is the same.

In case closer accuracy is essential, from the data now in our possession new coefficients could be calculated for each variable head; the same relative difference, however, would be preserved in the flow at both points,—which I have regarded as the more special object of our investigations.

The circumstances under which the gaugings here presented were made have been so favorable that I feel great confidence in offering them to you as reliable and sufficient.

Very faithfully,

THEODORE WESTON.

Jas. P. Kirkwood, Esq.,
Ch. Engr. B. W. W.

[F.]

TABLE SHOWING ADDITIONAL FLOW OF WATER ON WATTS' CREEK, BETWEEN VALLEY STREAM AND WATTS' PONDS.

VALLEY-STREAM POND.					WATTS' POND.				
DATE.	Hour.	Depth of flow, in feet.	Cubic Feet per second.	N. Y. Gallons per 24 hours.	DATE.	Hour.	Depth of flow, in feet.	Cubic Feet per second.	N. Y. Gallons per 24 hours.
		Feet.	Cub. ft.	Gallons.			Feet.	Cub. ft.	Gallons.
Aug. 4...	11 A.M.	0.245	2.7249	1,838,724	Aug. 4...	11 A.M.			
" " ..	12 M.	0.255	2.8935	1,905,243	" " ..	12 M.			
" " ..	3 P.M.	0.245	2.7249	1,838,724	" " ..	3 P.M.	0.480	4.3136	2,910,043
" " ..	6 "	0.300	3.6922	2,491,436	" " ..	6 "	0.520	4.3309	2,924,439
" 5...	6 A.M.	0.320	4.0675	2,744,696	" 5...	6 A.M.	0.720	7.9226	5,346,086
" " ..	8 "	0.315	3.9725	2,680,610	" " ..	7 "	0.725	8.0053	5,401,877
" " ..	10 "	0.310	3.8783	2,617,042	" " ..	9 "	0.710	7.7582	5,235,096
" " ..	12 M.	0.335	4.3568	2,939,916	" " ..	11 "	0.700	7.5946	5,124,892
" " ..	2 P.M.	0.325	4.1632	2,802,805	" " ..	12 M.	0.695	7.5136	5,070,837
" " ..	4 "	0.510	8.1838	5,522,439	" " ..	2 P.M.	0.880	10.7052	7,223,721
" " ..	6 "	0.550	9.1653	6,184,614	" " ..	4 "	0.975	12.4847	8,424,519
" " ..	8 "	0.585	10.0540	6,784,239	" " ..	6 "	1.025	13.4570	9,080,788
" " ..	10 "	0.600	10.4431	7,046,823	" " ..	8 "	1.085	14.6560	9,889,704
" 6...	12 Mid.	0.600	10.4431	7,046,823	" " ..	10 "	1.100	14.9610	10,095,280
" " ..	2 A M.	0.600	10.4431	7,046,823	" 6...	12 Mid.	1.130	15.5772	10,511,000
" " ..	4 "	0.595	10.3119	6,958,943	" " ..	2 A.M.	1.120	15.3709	10,372,047
" " ..	6 "	0.590	10.1858	6,871,529	" " ..	4 "	1.115	15.2681	10,302,665
" " ..	8 "	0.580	9.9253	6,697,445	" " ..	6 "	1.100	14.9610	10,095,280
" " ..	10 "	0.570	9.6697	6,525,000	" " ..	8 "	1.080	14.5549	9,821,407
" " ..	12 M.	0.560	9.4056	6,354,039	" " ..	10 "	1.060	14.1524	9,549,848
" " ..	2 P.M.	0.550	9.1653	6,184,614	" " ..	12 M.	1.030	13.5359	9,147,528
					" " ..	2 P.M.	0.950	12.0070	8,102,574

Table carried forward.

TABLE.—(*Continued.*)

VALLEY-STREAM POND.					WATTS' POND.				
DATE.	Hour.	Depth of flow, in feet.	Cubic Feet per second.	N. Y. Gallons per 24 hours.	DATE.	Hour.	Depth of flow, in feet.	Cubic Feet per second.	N. Y. Gallons per 24 hours.
		Feet.	Cub. ft.	Gallons.			Feet.	Cub. ft.	Gallons.
Aug. 6...	4 P.M.	0.540	8.9129	6,016,755	Aug. 6...	4 P.M.	1.035	13.6550	9,214,000
" "..	6 "	0.535	8.7682	5,916,700	" "..	6 "	1.035	13.6550	9,214,000
" "..	8 "	0.525	8.5475	5,767,746	" "..	8 "	1.025	13.4778	9,080,791
" "..	10 "	0.515	8.2094	5,539,625	" "..	10 "	1.010	13.1630	9,089,770
" 7...	12 Mid.	0.500	7.9443	5,360,716	" 7...	12 Mid.	0.955	12.8780	8,684,920
" "..	2 A.M.	0.490	7.7072	5,188,720	" "..	2 A.M.	0.950	12.0070	8,103,506
" "..	4 "	0.480	7.4724	5,042,302	" "..	4 "	0.900	11.0722	7,471,389
" "..	6 "	0.465	7.1249	4,807,810	" "..	6 "	0.865	10.4336	7,039,824
" "..	8 "	0.455	6.8963	4,653,548	" "..	8 "	0.850	10.6250	6,857,531
" "..	10 "	0.445	6.6702	4,500,985	" "..	10 "	0.890	10.8882	7,347,215
" "..	12 M.	0.435	6.4467	4,350,120	" "..	12 M.	0.900	11.0723	7,471,389
" "..	2 P.M.	0.420	6.1161	4,127,068	" "..	2 P.M.	0.875	10.6141	7,162,262
" "..	4 "	0.415	6.0072	4,053,588	" "..	4 "	0.865	10.4336	7,039,824
" "..	6 "	0.405	5.7914	3,907,962	" "..	6 "	0.830	9.8060	6,616,109
" "..	8 "	0.405	5.7914	3,907,962	" "..	8 "	0.835	9.8946	6,676,785
" "..	10 "	0.405	5.7914	3,907,962	" "..	10 "	0.830	9.8060	6,616,909
" 8...	12 Mid.	0.395	5.5782	3,764,076	" 8...	12 Mid.	0.815	9.5413	6,438,342
" "..	2 A.M.	0.390	5.4727	3,692,873	" "..	2 A.M.	0.820	9.6293	6,497,686
" "..	4 "	0.385	5.3678	3,622,087	" "..	4 "	0.800	9.2802	6,262,139
" "..	6 "	0.380	5.2645	3,470,804	" "..	6 "	0.795	9.1923	6,202,350
" "..	7 "	0.375	5.1600	3,481,877	" "..	7 "	0.800	9.2802	6,262,139
" "..	8 "	0.370	5.0572	3,412,409	" "..	8 "	0.800	9.2802	6,262,139

Table carried forward.

TABLE.—(*Concluded.*)

VALLEY-STREAM POND.					WATTS' POND.				
DATE.	Hour.	Depth of flow, in feet.	Cubic Feet per second.	N. Y. Gallons per 24 hours.	DATE.	Hour.	Depth of flow, in feet.	Cubic Feet per second.	N. Y. Gallons per 24 hours.
		Feet.	Cub. ft.	Gallons.			Feet.	Cub. ft.	Gallons.
Aug. 8...	9 A.M.	0.370	5.0572	3,412,409	Aug. 8...	9 A.M.	0.800	9.2802	6,262,139
" "...	10 "	0.365	4.9550	3,343,541	" "...	10 "	0.790	9.1057	6,144,383
" "...	11 "	0.360	4.6536	3,275,116	" "...	11 "	0.780	8.9334	6,028,095
" "...	12 M.	0.360	4.6536	3,275,116	" "...	12 M.	0.775	8.8476	5 970,217
" "...	1 P.M.	0.355	4.7528	3,207,084	" "...	1 P.M.	0.770	8.7602	5,912,561
" "...	2 "	0.355	4.7528	3,207,084	" "...	2 "	0.765	8.6769	5,855,039
" "...	3 "	0.355	4.7528	3,207,084	" "...	3 "	0.755	8.5073	5,741,589
" "...	4 "	0.350	4.6527	3,139,567	" "...	4 "	0.750	8.4229	5,683,679
" "...	5 "	0.350	4.6527	3,139,567	" "...	5 "	0.750	8.4229	5,683,679
" "...	6 "	0.345	4.5533	3,072,532	" "...	6 "	0.745	8.3388	5,626,935

FORMULA USED.—$Q=5.35\ mlH\sqrt{H}$.

Q=cubic feet discharged per second.

5.35=theoretical constant=$\frac{2}{3}\sqrt{2gh}$.

l=length of weir=7 feet.

m=coefficient of correction=0.600.

H=head on weir.

FORMULA.—$Q=5.35\ mlH\sqrt{H}$.

Q=cubic feet discharged.

$5.35=\frac{2}{3}\sqrt{2gh}$=theoretical constant.

l=length of weir=3.645 feet.

m=coefficient of correction=0.665.

H=head on weir.

[H.]

Observations on the Specific Gravity of Water along the shore of Jamaica Bay.

Green's Standard Hydrometer used. Distilled Water at 60° *Fahr.*=1000.

DATE.	LOCALITY.	High Tide.	Ebb Tide.	Low Tide.	Flood Tide.	Temperature of Water.	Wind.
1860.							
Sept. 24.	Mouth of Jamaica Creek (at D on map)...	1016	1014			73°	S. E.
" 25.	" " "	1017	1012			68°	N.W.
" 26.	" " "		1010	10035		63°	Calm.
" 27.	" " "		1015		1013	59°	"
Sept. 24.	About 900 feet from mouth (at C on map).	1015	1014			73°	S. E.
" 25.	" " "		1010			68°	N.W.
" 26	" " "			1001		63°	Calm.
" 27.	" " "				1007	59°	"
Sept. 24.	Half-Way Creek (at B on map)..........	1016				79°	S. E.
" 25.	" "		1006			68°	N.W.
" 26.	" "			1000½		63°	Calm.
" 27.	" "		1008		1003½	59°	"
Sept. 24.	At Boat-House, near Mill (A on map).....	1014				73°	S. E.
" 25.	" "		1008			68°	N.W.
" 26.	" "		1002½	1000		63°	Calm.
" 27.	" "		1005½		1003½	59°	"
Sept. 24.	Long Neck Point (at E on map)..........	1017				70°	S. E.
" 25	" "		1018			70°	N.W.
" 26.	" " (at E′ on map).........		1017			63°	Calm.
" 27.	" "				1018⅓	62°	"
Sept. 24.	Mouth of Springfield Creek (at F on map).	1014½				73°	S. E.
" 25.	" " "		1016			69°	N.W.
" 26.	" " "			1012		69°	Calm.
" 27.	" " "			1009		69°	"
Sept. 24.	Mouth of Long Neck Creek (at G on map).	1017					S. E.
" 25.	" " "		1017				N.W.
" 26.	" " "			1015			Calm.
Sept. 26.	At H on map.........................		1017	1015			"
" "	" "		1017	1016			"
Sept. 27.	In Broad Channel (at I on map)..........		1019			64°	"
" "	" " further south..........		1020			64°	"
" "	" " opposite Sea-side House.		1020¼			63°	"
" "	" " " "			1020	1020	62°	"
" "	At Broad Channel Point................				1019	62°	"
" "	*Sea water from outside Rockaway Beach...*			1025	1025	67°	"
" 26	Water from Salt Creek, running into main channel.........................			1017		66°	"

WEATHER.

Sept. 24.—Windy from the S. E.
" 25.— " " N. W.
" 26.—Calm. Unusually low tide in Bay, at 11h. 30m. A. M.
" 27.— " Usual low water at 12 M.

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